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**PLEASE NOTE: If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!**

*Lab Day (T/W/Th/F): Tuesday*

*Lab Week (even/odd): odd*

*Lab time (10:00, 2:30, 6:30): 2.30*

# **Laboratory Report Form**

## **Experiment 2.**

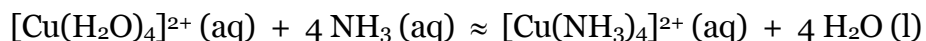
### **Equilibria**

#### **Checklist:**

- **Raw Data Sheet written in pen, signed by TA and attached**
- **Completed Report Form attached**

*Student's Initials :OAI*

Table 1. Observations and Discussion



***Initial Observations***

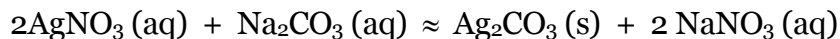
- $\text{CuSO}_4$ -light blue colour, faint smell odour
- $\text{NH}_3$ -Transparent colour, very strong odour.
- $\text{HCl}$ -transparent colour and faint smell odour.

***Final Observations***

- Adding 10 drops of  $\text{NH}_3$  to the solution of 20 drops  $\text{CuSO}_4$  turns the solution dark blue in colour and also has a very strong odour.
- Adding 10 drops of  $\text{HCl}$  into the same solution turns it blue purple with a faintly strong smell
- Adding  $\text{NH}_3$  back to the same solution turns it dark blue back with a faintly strong smell, a dark blue colour was formed at the meniscus.
- Adding  $\text{HCl}$  back to the same solution turned it blue purple back with a faint smell, also a dark blue colour was formed at the meniscus.

***Discussion***

- For the first step, adding  $\text{NH}_3$  to  $\text{CuSO}_4$  causes a displacement between the  $\text{Cu}$  and  $\text{NH}_3$ , thus changing the colour from light blue to dark blue and shifting the equilibrium to the right to consume the excess  $\text{NH}_3$  ion added in the solution.
- Adding  $\text{HCl}$  to the same solution causes the equilibrium to shift back to the original position to consume the excess  $\text{H}^+$  ion formed, thus forming  $\text{Cu}(\text{NH}_3)_4^{2+}$
- As we repeated step 2-3, the equilibrium is moving from left to right when  $\text{NH}_3$  is added and moves from right to left when  $\text{HCl}$  is added to consume the excess  $\text{HCl}$  and  $\text{NH}_3$  ions of each respective reactions. The reaction can also be explained using the LeChatelier's principle which states a reaction will always move in the direction that minimizes the effect of any change involved in a system at equilibrium.



***Initial Observations***

- $\text{Na}_2\text{CO}_3$ -Transparent colour with no smell
- $\text{AgNO}_3$ -Transparent colour with no smell

***Final Observations***

- Adding  $\text{AgNO}_3$  to 0.1 Mol/l of  $\text{Na}_2\text{CO}_3$  causes a change in appearance from a transparent colour to a dark-yellowish colour with a faint smell and also formation of particles at the top of the solution

**Discussion**

- In the first reaction, there is a precipitate formed due to the double displacement between  $\text{AgNO}_3$  and  $\text{Na}_2\text{CO}_3$  thus, causing the reaction to reach equilibrium and shifting it to the right .

**Initial Observation (Adding  $\text{HNO}_3$  to the same solution)**

- $\text{HNO}_3$ -a Transparent liquid, with no smell

**Final Observation**

- Adding  $\text{HNO}_3$  to the solution causes a change in appearance from dark yellowish brown to a transparent solution with no precipitate formed (particles disappeared)

**Discussion**

- When  $\text{HNO}_3$  is added to the same solution, there is in fact an increase in the number of  $\text{H}^+$  ions in the solution, it increases the number of  $\text{CO}_3^{2-}$  produced thus shifting the equilibrium to the right.

**Initial Observation (Adding  $\text{HCl}$  to the same solution when clear)**

- $\text{HCl}$ - transparent with no smell

**Final Observation**

- Adding  $\text{HCl}$  to the clear solution turns the solution milky and also has a faint smell.

**Discussion**

- The equilibrium will shift to the right because of the addition of a strong acid to the solution thus adding to the  $\text{Ag}^+$  and  $\text{CO}_3^{2-}$  ions present in the solution.

**Initial Observation (Adding  $\text{NH}_3$  to the same solution)**

- $\text{NH}_3$ -transparent and very strong smell

**Final Observation**

- Adding  $\text{NH}_3$  to the solution turns it back to a transparent solution with a very strong smell.

**Discussion**

- $\text{NH}_3$  will mix with the solution and dissolve  $\text{AgCl}$  which will then form  $\text{Ag}(\text{NH}_3)_2^+$  ions. So equilibrium will favour the forward reaction due to the  $\text{Ag}^+$  and  $\text{NH}_3$  ions present in the solution.

**Initial Observations ( Adding  $\text{HNO}_3$  and  $\text{NH}_3$  again to the same solution)**

- $\text{HNO}_3$ -a transparent liquid with no smell.
- $\text{NH}_3$ - a transparent liquid with a strong smell

**Final Observations**

- Adding  $\text{HNO}_3$  to the solution turns it back milky with a faint smell and gas was released and the solution became hot.
- After, Adding  $\text{NH}_3$  back to the same solution turns it back to a clear solution with a strong odour and gas was released.

**Discussion**

- After adding  $\text{HNO}_3$  to the solution, it heated up and a gas was formed, then adding  $\text{NH}_3$  to the solution allowed the  $\text{HCl}$  present to dissociate with the  $\text{AgCl}$  and thus the  $\text{H}^+$  ion left mixed with  $\text{NH}_3$  and converted it to  $\text{NH}_4^+$

**Initial Observation (adding  $\text{KI}$  to the same solution)**

- $\text{KI}$ -a transparent and colourless liquid with no smell

**Final Observation**

- Adding KI to the solution turns its colour milky with a faint odour.

**Discussion**

- Adding KI to the reaction would affect the equilibrium change because KI is not compatible with the reaction and thus has no effect on its equilibrium.

**Initial Observation(Adding Na<sub>2</sub>S to the same solution)**

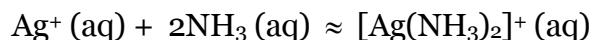
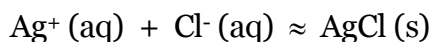
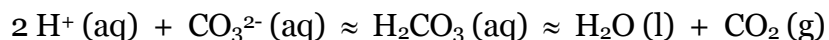
- Na<sub>2</sub>S -A clear solution with a strong bad odour.

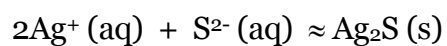
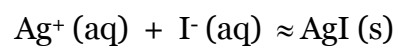
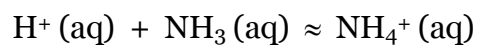
**Final Observation**

- Adding Na<sub>2</sub>S to the solution turns it non-transparent brown with a strong pungent smell. A precipitate was formed.

**Discussion**

A precipitate was formed because Na<sub>2</sub>S is not very soluble in water and thus it does not dissociate completely in water and does not affect the equilibrium shift for this reaction.





***Initial Observations***

- $\text{CH}_3\text{COOH}$ -transparent colour and a faint smell.
- Universal indicator-red in colour with a faint sweet smell.
- $\text{NaCH}_3\text{COO}$ -transparent colour and with no smell
- $\text{NaOH}$ -transparent colour with faint smell

### ***Final Observation***

#### ***Buffer***

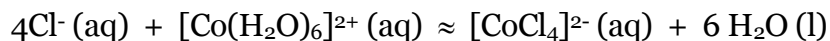
- Adding the universal indicator to two wells containing CH<sub>3</sub>COOH turns the solution red with a faint strong smell and the pH recorded was a value of 3 that was a medium orange colour
- Adding NaCH<sub>3</sub>COO to the both wells containing the same solution of the universal indicator and CH<sub>3</sub>COOH caused a change in colour to a light-orange colour with a pH value of 4
- HCL was then added to the first well in which the pH value became approximately 2 ( a dark orange colour)
- NaOH was then added to the second well in which the pH was 7 ( light green colour)

#### ***Distilled water***

- Adding the universal indicator to the two wells containing the distilled water which the pH was 3 ( medium orange colour)
- Adding 5 drops HCL to the one of well containing the distilled water and the pH was approximately 4 ( a light orange colour)
- Adding 5 drops NaOH to the other well, the pH value was a 9(dark green colour)

#### ***Discussion***

- Addition of HCL to the well of H<sub>2</sub>O and CH<sub>3</sub>COOH increases the H<sup>+</sup> ion on the product side thus, shifting the equilibrium to the left to consume the excess H<sup>+</sup> ion and also increases the concentration of H<sub>2</sub>O AND CH<sub>3</sub>COOH.
- Addition of NaOH to the other well of H<sub>2</sub>O and CH<sub>3</sub>COOH increases the number of OH<sup>-</sup> ion .thus, shifting the equilibrium from the reactants side to the products side in order to consume the excess OH<sup>-</sup> ions.



#### ***Initial Observations***

- CoCl<sub>2</sub>- red wine colour with a normal smell
- 12M HCL- transparent colour with a very strong odour

#### ***Final Observations***

- Adding 12M HCL to a CoCl<sub>2</sub> solution turns its colour to blue with a very strong smell.
- Adding H<sub>2</sub>O to the same solution turns it pink with a faint smell.

#### ***Discussion***

- Adding HCL to the solution caused a change in colour to blue because of the CL<sup>-</sup> ion that is in contact with the Co<sup>2+</sup> due to the common ion effect which ionizes HCL and then produces (CoCl<sub>4</sub>)<sup>2+</sup>.
- As water is added to the equation, it will shift to the left side of the reaction because of the H<sub>2</sub>O present in the right side of the reaction.

#### ***Intial Observation( CuBr<sub>2</sub> + H<sub>2</sub>O)***

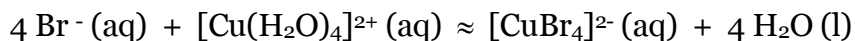
- CuBr<sub>2</sub>-Ash in colour with a faint smell.

***Final Observation***

- Adding water to a CuBr<sub>2</sub> solution turns it green in colour with a faint smell.

***Discussion***

Adding water to the reaction causes a shift in equilibrium to the left as water is a product in the reaction.



***Initial Observation***

- KBr- light pink in colour and has a faintly strong smell.

***Final Observation***

- Adding CuBr<sub>2</sub>+H<sub>2</sub>O to KBr causes a change in colour to blueish green due to heating up in a test tube.

***Discussion***

- After adding KBr to the solution, there is most likely to be enough bromine to cover the colour of the decomposing bromine ion
- When heating of the solution is finished H<sub>2</sub>O molecules would leave the solution to form steam.

***Initial Observation(CoCl<sub>2</sub>+12M HCL +H<sub>2</sub>O+temperature effect)***

- CoCl<sub>2</sub>- red wine colour

***Final Observation***

- It turns transparent when exposed to heat and has a faint smell.

***Discussion***

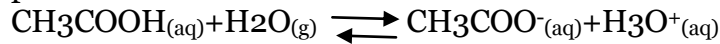
- The CoCl<sub>2</sub> is an endothermic reaction so it would favour the right side of the reaction, but under normal condition it would favour the left side of the reaction.

### Calculations:

Find the Difference in pH of H<sub>2</sub>O+ Buffer after the addition of strong base and acid

1. pH of H<sub>2</sub>O-7.0

2. pH of Buffer-



• Drops: 10 dr/g(0.1mol/l) for CH<sub>3</sub>COOH

• Drops: 10 dr/g(0.1mol/l) for CH<sub>3</sub>COO

(CH<sub>3</sub>COOH): (0.1 mol/l)(10dr/g / 20dr/g)=0.05mol/l

(CH<sub>3</sub>COO): (0.1mol/l)(10dr/g / 20 dr/g)=0.05mol/l

Henderson-Hasselbalch (acid form)

$$\text{PH} = \text{pKa} + \text{Log}(\text{A}^-/\text{HA})$$

Where (HA)=acid concentration

(A<sup>-</sup>)=conjugate base

$$\text{Ka}(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$$

$$\text{PH} = -\log(\text{H}^+)$$

$$\text{POH} = -\log(\text{OH}^-)$$

$$\text{pKa} = -\log \text{Ka}$$

$$\text{PH} = (1.8 \times 10^{-5}) + \log(0.05/0.05)\text{mol/l}$$

$$\text{PH} = 4.74.$$

3. PH of H<sub>2</sub>O +HCL:

$$(\text{HCL})_{\text{intial}} = 0.1\text{mol/l}, V_{\text{intial}} = 5 \text{ dr/g}$$

$$V_{\text{H}_2\text{O}} = 20 \text{ dr/g}, V_{\text{final}} = 25\text{dr/g}$$

From the equation we know  $C_i V_i = C_F V_F$

$$C_F = (C_i V_i) / V_F$$

$$C_F = (0.1\text{mol/l})(5\text{dr/g}) / (25\text{dr/g})$$

$$C_F = 0.02\text{mol/l}$$

$$C_F = (\text{HCL})_F = (\text{H}^+)$$

$$\text{PH} = -\log(\text{H}^+)$$

$$\text{PH} = -\log(0.02)$$

$$\text{PH} = 1.70$$

4. PH of H<sub>2</sub>O +NAOH:

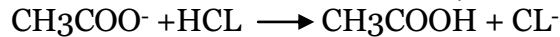
$$(\text{NAOH})_F = (\text{OH}^-)$$

$$\text{PH} + \text{POH} = 14.00$$

$$\text{POH} = 14.00 - 1.70$$

$$\text{POH} = 12.3$$

5. PH of Buffer + HCL (CH<sub>3</sub>COOH/CH<sub>3</sub>COO)



$$V_f = 25\text{dr/g}$$

$$V(\text{CH}_3\text{COO}^-) = 10 \text{ dr/g} (0.10 \text{ mol/l})$$

$$V(\text{HCL}) = 5 \text{ dr/g} (0.10\text{mol/l})$$

$$V(\text{CH}_3\text{COOH}) = 10 \text{ dr/g} (0.10\text{mol/l})$$

$$(\text{CH}_3\text{COO}^-) = (0.10\text{mol/l})(10/25 \text{ dr/g})$$

$$(\text{CH}_3\text{COO}^-) = 0.04\text{mol/l}$$

$$(\text{HCL}) = (0.10\text{mol/l})(5/25 \text{ dr/g})$$

$$(\text{HCL}) = 0.02\text{mol/l}$$

$$(\text{CH}_3\text{COOH}) = (0.10\text{mol/l})(10/25 \text{ dr/g})$$

$$(\text{CH}_3\text{COOH}) = 0.04\text{mol/l}$$

	$\text{CH}_3\text{COO}^- + \text{HCl} \longrightarrow \text{CH}_3\text{COOH} + \text{Cl}^-$				
Initial concentration(mol/l)	0.04	0.02	0.04		
Change in concentration(mol/l)	-0.02	-0.02	+0.02		
Equilibrium	0.02	-	0.06		

$$\text{PH} = \text{pKa} + \log(\text{A}^- / \text{HA})$$

$$\text{PH} = 4.74 + \log(0.02 / 0.06 \text{ mol/l})$$

$$\text{PH} = 4.74 - 0.48$$

$$\text{PH} = 4.26$$

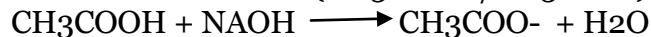
Change in Buffer + HCL

$$\text{PH} = \text{PH final} - \text{PH initial}$$

$$\text{PH} = 4.26 - 4.74$$

$$\text{PH} = -0.48$$

6. PH of Buffer + NAOH( $\text{CH}_3\text{COOH}/\text{CH}_3\text{COO}^-$ )



$$V_f = 25 \text{ dr/g}$$

$$V(\text{CH}_3\text{COOH}) = 10 \text{ dr/g}(0.10 \text{ mol/l})$$

$$V(\text{NAOH}) = 5 \text{ dr/g}(0.10 \text{ mol/l})$$

$$V(\text{CH}_3\text{COO}^-) = 10 \text{ dr/g}(0.10 \text{ mol/l})$$

$$(\text{CH}_3\text{COOH}) = (0.10 \text{ mol/l})(10/25) \text{ dr/g}$$

$$(\text{CH}_3\text{COOH}) = 0.04 \text{ mol/l}$$

$$(\text{NAOH}) = (0.10 \text{ mol/l})(5/25) \text{ dr/g}$$

$$(\text{NAOH}) = 0.02 \text{ mol/l}$$

$$(\text{CH}_3\text{COO}^-) = 0.04 \text{ mol/l}$$

	$\text{CH}_3\text{COOH} + \text{NAOH} \longrightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$				
Initial Concentrations(mol/l)	0.04	0.02	0.04		
Change in Concentration(mol/l)	-0.02	-0.02	+0.02		
Equilibrium	0.02	-	0.06		

$$\text{PH} = \text{pKa} + \log(\text{OH}^- / \text{H})$$

$$\text{PH} = 4.74 + \log(0.06 / 0.02)$$

$$\text{PH} = 4.74 + 0.48$$

$$\text{PH} = 5.22$$

Change in PH for buffer + base

$$\text{PH} = \text{PH final} - \text{PH initial}$$

$$\text{PH} = 5.22 - 4.74$$

$$\text{PH} = 0.48$$

**Additional Discussion (if desired....otherwise, discussion can be combined with the observations in the table):**

**Conclusion:**

There are various ways to determine the equilibrium on a reaction and the lab experiment conducted shows us some different examples on how different effects can change the equilibrium of a system either favouring the products or the reagents side of the reaction. In this lab we analysed how addition of strong acid

and bases such as HCL and NAOH can affect the equilibrium of a system, also the addition of temperature to a reaction would mostly favour the product side of such reaction because increase in temperature would lead to an increase in the product. Precipitate formed can also cause a change in equilibrium to one side either product or reactants because it would want to consume the excess products or reactants formed. Common ion effect would also affect the equilibrium of a reaction because it would produce an ion that is in the reaction such as  $\text{NH}_3$  to  $\text{NH}_4^+$  which will continue to increase its concentration and then forming a solution.

Buffer effects were also proved in this lab experiment such as:

Adding water to acid(HCL) changed its PH to 4(light orange)

Adding water to base (NAOH)changed its PH to 9(dark green)

Adding buffer to acid (HCL) changed its PH to 2(orange)

Adding buffer to base (NAOH) changed its PH to 7(light green)

Thus, showing that buffer and water can also affect the PH of a reaction and colour changes were also observed.